1910

A study of the efficiency of discharge of classifier spigots

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THESIS

Degree of Bachelor of Science.

A STUDY OF THE EFFICIENCY OF DISCHARGE OF CLASSIFIER SPIGOTS.

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Approved Boyd Dudley Jr. May 20, 1910.

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A knowledge of the amounts of water and sand that will be discharged by classifier spigots under various conditions is of considerable importance in the design of classifiers. Suppose it is desired to discharge fifty tons of sand with an average diameter of 2 m.m. through a spigot orifice, the sand being mixed with 100 tons of water and the entire amount of the mixture being discharged in ten hours from the spigot, which is submerged to a depth of two feet under the water. How large a spigot is required? Problems such as this are by no means uncommon. While in many cases they may be solved by guess and trial, still the knowledge of even a limited amount of data on the subject would materially increase the accuracy of guesses and decrease the number of trials necessary to a solution of the particular problem. It was with the idea of securing such data and determining the influence of various factors upon efficiency of discharge of classifier spigots that this investigation was started.

The efficiency of discharge of a spigot for mixtures of water and sand is governed by many variables, some important and others relatively unimportant. Apparently among the most important are the following, the particular design of the spigot and the character of the column through which the pulp passes before reaching the spigot, the ratio of the size of ore grain to the size of the spigot orifice, and the ratio of water to sand in the pulp. Owing to the lack of time only one particular design of sorting column was studied. Therefore no conclusions were reached in regard to this factor. The influence of the ratio of the diameter of ore grain to the diameter of the spigot orifice was considered only incidentally. The effect upon the efficiency of varying the ratio of water to sand was given the greatest amount of attention, and all of the experiments were performed with a view of securing information on this point.

The arrangement of the apparatus, which consists of a classifier, two launders, spigots, and suitable support, is shown in Plate I.

The classifier was made of galvanized iron, the upper part being cylindrical in shape having a diameter of 16 inches and a length of ~~extending~~ 18.6 inches, terminating in a cone of 60 degrees, at the apex of which was attached a cylinder 4 inches in diameter and extending 12 inches making a total height of 46.6 inches. At one metre distant from the bottom slots were cut in the classifier which allowed the excess water to overflow into a launder which encircled the classifier. Attached to the sides of the classifier were angle irons which served as supports. A section of the classifier is shown in Plate II.

The spigots were made of soft wood, a glass tube being fitted into the perforated wooden plug. All of the tubes were cut with their length four times the diameter in order to eliminate any influence that a variable ratio of length to diameter might exert upon the discharge efficiency of the spigot. The remainder of the wooden plug was coned to an angle of 60 degrees, the total length of the spigot varying with the length of the glass tubing used. Four spigots in all were used, the diameters being as follows: 1.83 m.m., 6.3 m.m., 9.1 m.m., and 14.3 m.m. The spigots were inserted into the small cylinder of the classifier and made water tight by means of paraffine.

The two launders were made of wood, rectangular in shape and closed at one end.

The classifier was supported by means of a wooden frame work the drawing of which is self explanatory.

Plate No. 1

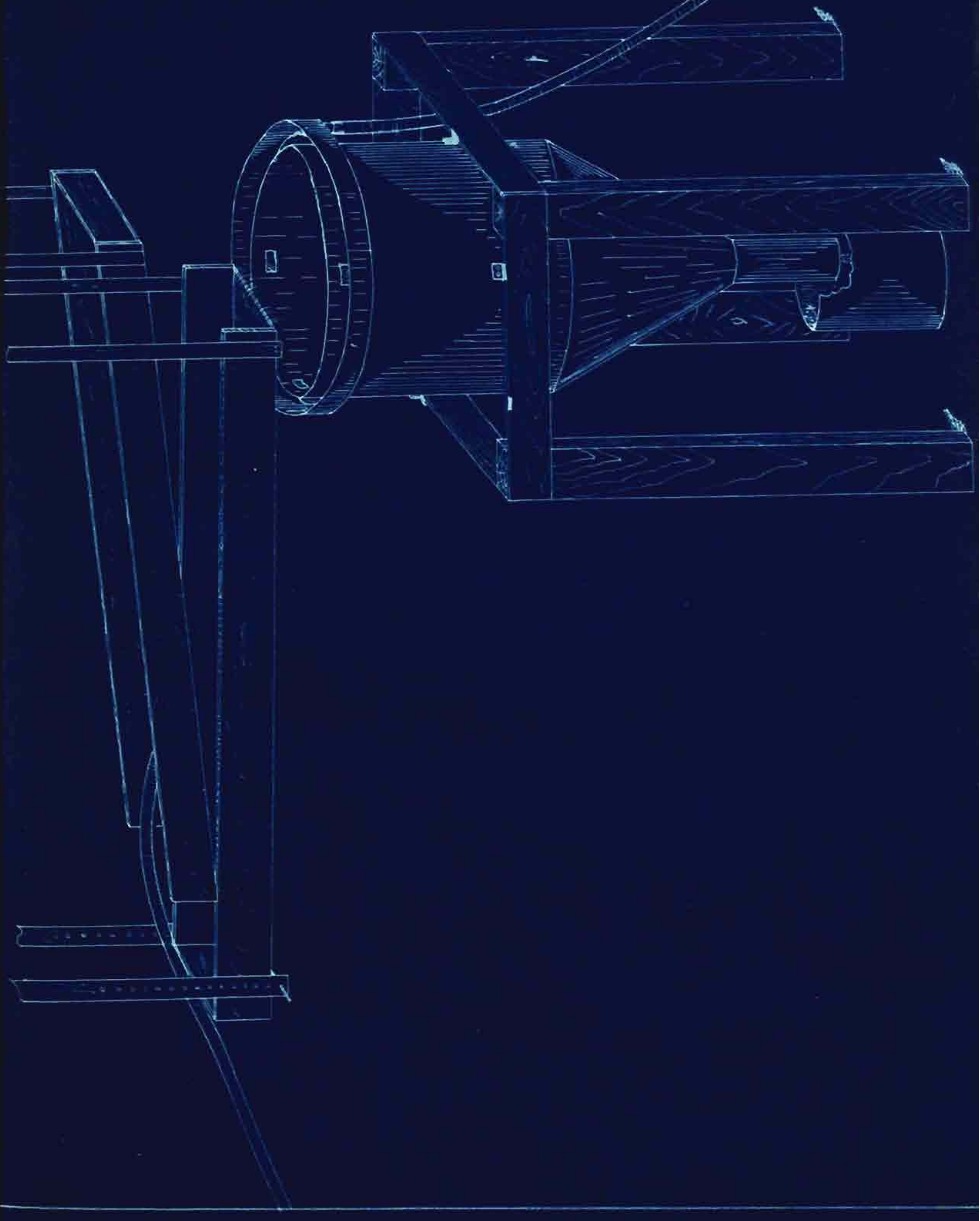
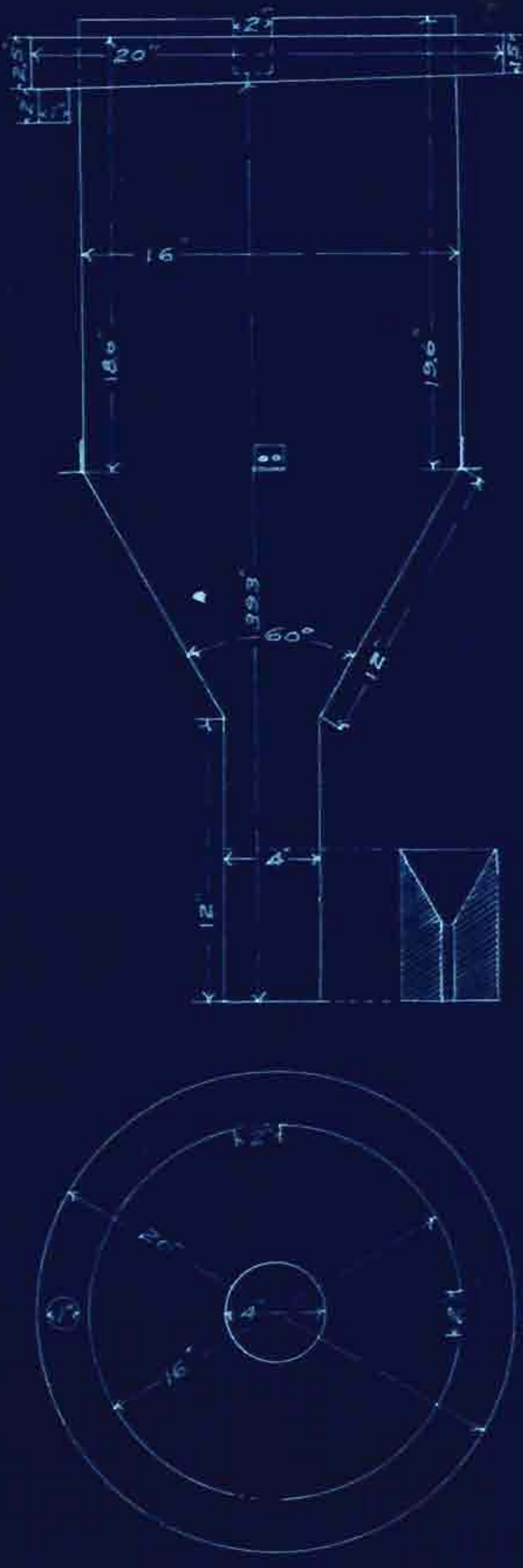


Plate No. 2



The first thing we did after getting the different parts of the apparatus was to assemble them in the most convenient manner, a sketch of the same is shown in Plate III.

The material used was a clean chert (Sp.Gr. 2.56) being sized through accurately measured screens, the average size grains being 0.373 m.m., 0.606 m.m., 0.855 m.m., 1.461 m.m., 2.972 m.m., and 4 m.m. in diameter respectively.

By experiments carried on by other parties, it was found that if a bank of ore was kept in a launder the water passing through would saturate itself with a constant amount of the ore and no more, this amount, however, varying with the slope of the launder and with the ~~on~~ amount of water used. This principle was adopted by us in this research work, and the classifier was fed by allowing the water to carry sand down the launder, This was found to be better than an automatic shaking feeder in that the amount of sand was kept approximately constant at each slope and also was much easier to feed. The two launders used were placed one above the other and sloping in opposite directions. The reasons for using two launders were twofold, first, to break the impulse of the water so that there would be no undue pressure on the surface of the water in the classifier directly underneath the spillway of the lower launder, which fed material to the classifier; and, second, so that we could handle the feeding of the sand much better in the lower launder, where the water current was uniform, than if just one launder was used for feed water and also as a place for feeding the sand.

The spigot was closed and the classifier filled with water, no sand being fed in during this operation. When the classifier was filled up to a certain point, this being one metre distant from bottom of spigot, the sand was then fed into the launder. It may be stated here that the sand was run through the classifier once in order to saturate it with water, for it proved by experiment that less amount of pulp (sand and water) issued from the spigot in the same length of time when the sand was dry ~~and~~ than when the sand was wet, the same size sand, same slope, and same spigot being used. The sand was fed into the launder and when the pulp was coming out of the spigot at a uniform rate, it was deflected into a jar, the time being noted by means of a stop-watch. When the jar had become filled up to a certain point at or near one of the gauging points, the pulp was deflected into a refuse box, time again being noted. Before entering the refuse box, the pulp was passed over a screen, the sand remaining on the surface and the water passing through. The jar, the weight of which was known, with its contents of pulp was carefully weighed. The weight of pulp was calculated by difference in weight. The volume of pulp was also recorded. The jar was cleaned and the experiment repeated, all variables remaining the same for two or more of these experiments, - the time, weight, and volume being recorded in each case. After a sufficient amount of data had been taken ~~on~~ with one slope, ~~same~~ one size of sand, and ~~same~~ one size of spigot being used, the slope was then increased, the same routine as described above being followed. The slope was gradually increased until the amount of sand carried by the water was too much for the spigot to discharge without clogging. The lower launder was then dropped to the lowest slope and more data taken with different sized sand. When all the different sized sands were used that could be on one spigot, that spigot was taken out and another one put in. The same method of taking data was used on all spigots, a record of each being kept.

Using the data thus obtained, the results and method of calculation are given on the following page.

Wt. of jar and pulp - Wt.of jar = Wt.of pulp.

$\frac{\text{Wt.of pulp}}{\text{Seconds}}$ = Wt.of pulp per sec.

$\frac{\text{Vol.of pulp}}{\text{Seconds}}$ = Vol.per sec.

Let R = Ratio of water to sand by weight.

" p = Specific Gravity of pulp.

" d = Specific Gravity of sand.

Now consider "d" grams of sand discharged with "R" grams of water per second.

Let total weight discharged per sec.= W gms.

Then W = d+R.

Let total volume discharged per sec.= V cu.cm.

Since d+Rd = Wt.of pulp

Then $V = \frac{d+Rd}{p}$

But $1+Rd = V$

Therefore $1+Rd = \frac{d+Rd}{p}$

Hence $R = \frac{d - p}{dp - d}$

Putting in value of p = 2.56

We get $R = \frac{2.56 - p}{2.56p - d}$

The following table shows observed and calculated data, and a few words in way of explanation may make the table of data more clear.

The theoretical discharge on top and on bottom of spigots was calculated from the formula $Q = a\,v$ $v = \sqrt{2\,gh}$. Therefore $Q = a\sqrt{2gh}$

Q = Quantity of water.

a = Area of the spigot.

g = 980 (constant)

h = Height (This being one meter in one case and one meter minus length of tube in the other.)

"a" was calculated for each spigot, diameter being known in each case.

The size of pulp is the size of the average grain in each case.

The efficiency was obtained by dividing the actual discharge by the theoretical, the theoretical discharge used being the one on the bottom of the spigot.

—Data—

The Efficiency Of Discharge Of Pulp Through Classifier Spigots Of Different Design.

Derivation Of Formula.

Let p = Sp Gr of Pulp = $\frac{\text{Wt in grams}}{\text{Vol in cc}}$ or H_2O + Ore : d = Sp Gr Of Ore = 2.56

"R" = Ratio Of Water To Ore By Weight. $1 + Rd = \frac{d + Rd}{p}$

$p + Rdp = d + Rd \quad Rdp - Rd = d - p \quad \therefore R = \frac{d - p}{dp - d} = \frac{2.56 - p}{2.56 \times p - 2.56}$

THE HEAD IN ALL CASES = 1 METER

Area Of Spigot In Sq mm	Diam. Spigot In mm	Head On Top Of Spigot	Time In Secs	Litres H_2O + Ore	Grams H_2O + Ore	"R"	Wt Pulp Per Sec.	Vol Pulp Per Sec.	Theoretical Discharge On Top	Theoretical Discharge On Bottom	Size Of Pulp	Eff.
263.02	18.3	927	14.4	12.75	13279.	15.35	922.2	885.6	1121.6	1164.3	4 mm	76 %
"	"	"	13	[illegible]	12486.	5.42	960.0	861.5	"	"	"	74
"	"	"	13.3	11.62	12212.	11.6	918.0	873.5	"	"	"	75
"	"	"	14.1	12.89	13336.2	16.94	946.2	914.2	"	"	2.972	78.5
"	"	"	16.5	12.4	14695.7	3.78	890.7	751.5	"	"	"	64.5
"	"	"	13.6	11.84	13052.5	10.81	959.6	870.5	"	"	"	74.7
160.6	14.3	94.3	20.5	11.95	12312.7	22.82	600.5	583.0	686.5	708.3	"	85.3
"	"	"	21.6	12.19	13241.6	6.76	613.0	564.2	"	"	"	79.6
"	"	"	21.2	12.28	13109.2	8.95	618.2	579.7	"	"	"	81.8
"	"	"	20	12.28	12598.5	25.5	630.0	614.0	"	"	1.461	86.6
"	"	"	20	11.83	12655.2	8.76	632.5	591.0	"	"	"	83.4
"	"	"	21.9	12.55	13563.2	7.4	619.2	573.0	"	"	"	80.9
"	"	"	24.1	13.36	15492.7	3.62	642.7	554.7	"	"	"	78.3
65.03	9.1	96.36	9.0	2.19	2270.	16.9	252.2	243.3	252.4	287.7	"	84.5
"	"	"	10.0	2.44	2610.5	8.9	261.0	244.0	"	"	"	84.8
"	"	"	11.1	2.53	2894.2	5.4	260.7	227.9	"	"	"	79.2
"	"	"	9.8	2.45	2553.7	13.5	260.6	250.0	"	"	0.855	86.8
"	"	"	10.2	2.52	2780.7	6.62	272.6	247.1	"	"	"	85.9
"	"	"	14.7	2.50	3234.7	1.68	220.1	170.0	"	"	"	59.1
"	"	"	9.7	2.43	2630.3	7.39	271.2	250.5	"	"	0.606	87.0
"	"	"	10.7	2.56	2894.2	5.93	270.4	238.7	"	"	"	82.9
"	"	"	12.8	2.76	3291.5	2.72	257.1	214.9	"	"	"	74.4
"	"	"	13.0	2.57	3348.2	1.57	257.5	197.7	"	"	"	68.7
"	"	"	9.7	2.47	2496.5	77.6	257.3	254.6	"	"	0.373	88.5
"	"	"	9.6	2.42	2497.0	19.3	260.1	252.1	"	"	"	87.6
"	"	"	10.5	2.68	2894.2	7.34	275.6	255.2	"	"	"	88.7
"	"	"	11.0	2.65	2978.7	4.63	270.8	240.9	"	"	"	83.7
"	"	"	11.5	2.66	3132.6	3.95	272.4	231.1	"	"	"	80.2
"	"	"	9.8	2.56	2576.5	15.54	262.8	261.3	"	"	0.173	90.8
"	"	"	9.9	2.55	2576.5	77.5	260.2	257.6	"	"	"	89.5
"	"	"	9.7	2.47	2553.7	76.3	263.2	254.7	"	"	"	88.5
"	"	"	10.	2.56	2667.2	15.2	266.7	256.0	"	"	"	89.0
31.17	6.3	97.48	30.	3.80	2497.0			123.3	"	"	"	89.8
"	"	"	21.	2.47	2474.3	31.16	117.8	117.6	135.5	137.2	"	85.7
"	"	"	20.2	2.43	2440.2	15.56	120.8	120.3	"	"	"	87.7
"	"	"	21.6	2.5	2724	6.3	126.1	116.1	"	"	"	84.6
"	"	"	20.7	2.47	2553.7	76.4	123.4	119.3	"	"	0.373	86.9
"	"	"	21.4	2.56	2605.9	38.5	121.8	119.6	"	"	"	87.1
"	"	"	21.2	2.56	2655.9	31.16	125.3	120.7	"	"	"	87.9
"	"	"	21.1	2.51	2667.2	9.98	126.4	118.9	"	"	"	86.6
"	"	"	23.5	2.69	3007.7	3.41	128.0	110.2	"	"	"	80.3
"	"	"	20.4	2.51	2512.7	15.56	123.5	123.1	"	"	0.606	89.7
"	"	"	21.2	2.58	2633.2	30.8	124.2	121.7	"	"	"	88.7
"	"	"	21.4	2.49	2667.2	8.26	124.6	116.9	"	"	"	85.2
"	"	"	23.3	2.56	2905.6	4.19	124.7	109.8	"	"	"	80.0
"	"	"	25.4	2.59	3268.8	1.93	128.7	101.9	"	"		74.2

At the end may be seen the graphical representation of the calculated data. In looking at the curves it can be noticed that the efficiency increases gradually up to a certain point, this point being different in each case, as "R" increases. The point at which the abrupt change in the efficiency curve takes place approaches closer to the practical efficiency of pure water as the ratio between the size of sand and size of spigot increases. For example the large spigot, diameter 18.3 m.m., and the large sand, 4 m.m. in diameter, being used the abrupt change in the curve takes place when the efficiency is about 75% and "R" is about 5; while in the case of the small spigot, diameter 6.3 m.m., and the small sand, diameter 0.606 m.m., being used the abrupt change takes place when efficiency is about 80% and "R" is about 4. It was first thought that in plotting the efficiency and "R" the curve would show a gradual increase with no abrupt change, but this did not prove to be the case. In allcases the increase was gradual up to a certain point, then the abrupt change took place.

It is true the nearer we approach pure water the greater the efficiency will be, but this can hardly be used to advantage in practice; however, to use 20 times as much water as sand may be practical and this will give a fairly high efficiency of discharge no matter what size the sand grains may be or what size spigot is used as long as the sand grains are small enough to pass through the spigot without clogging it. A little care must be taken, however, as to the amount of pulp fed to the classifier for most of the pulp must exit through the spigot and it is possible to clog any machine by over feeding it.

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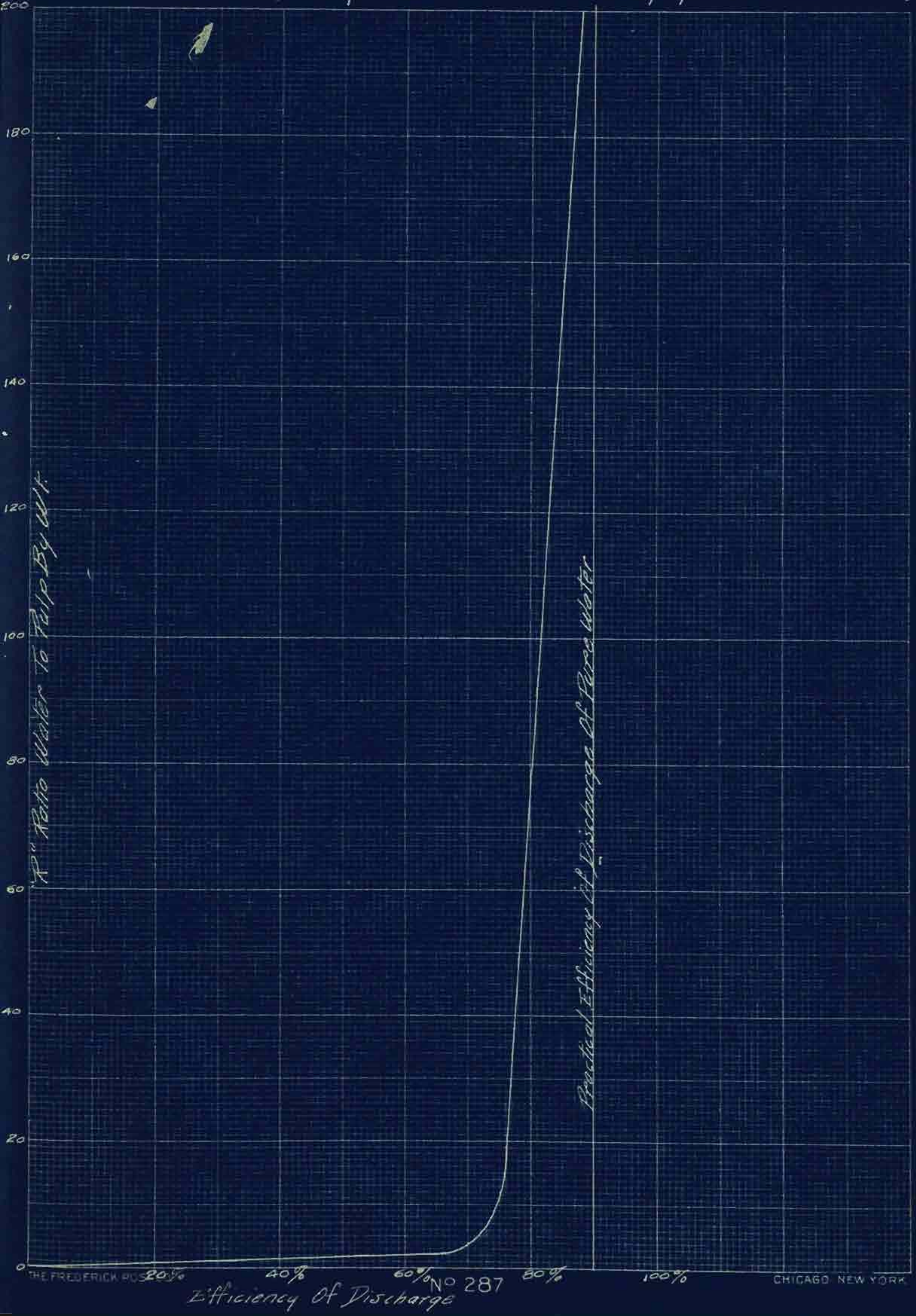
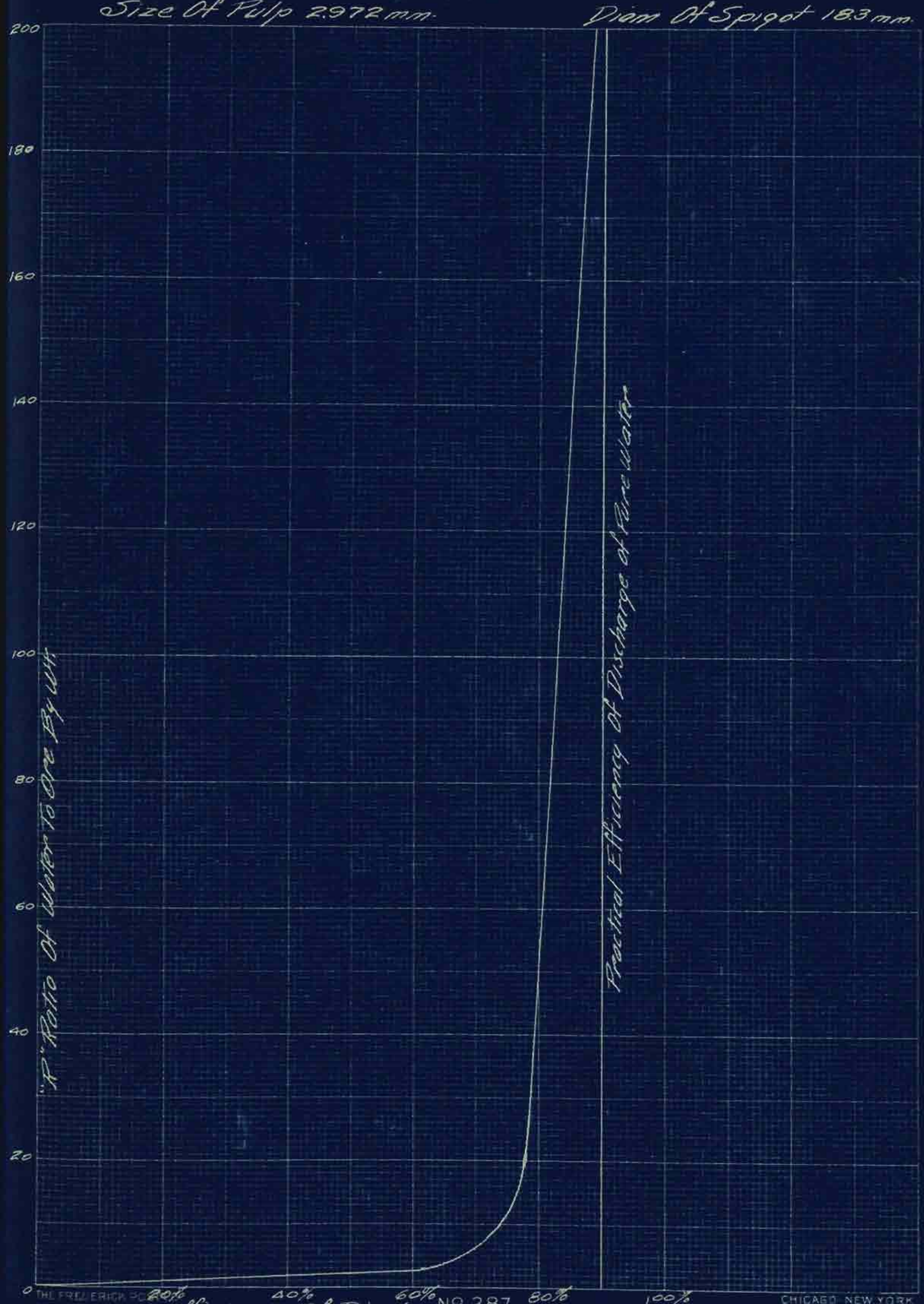
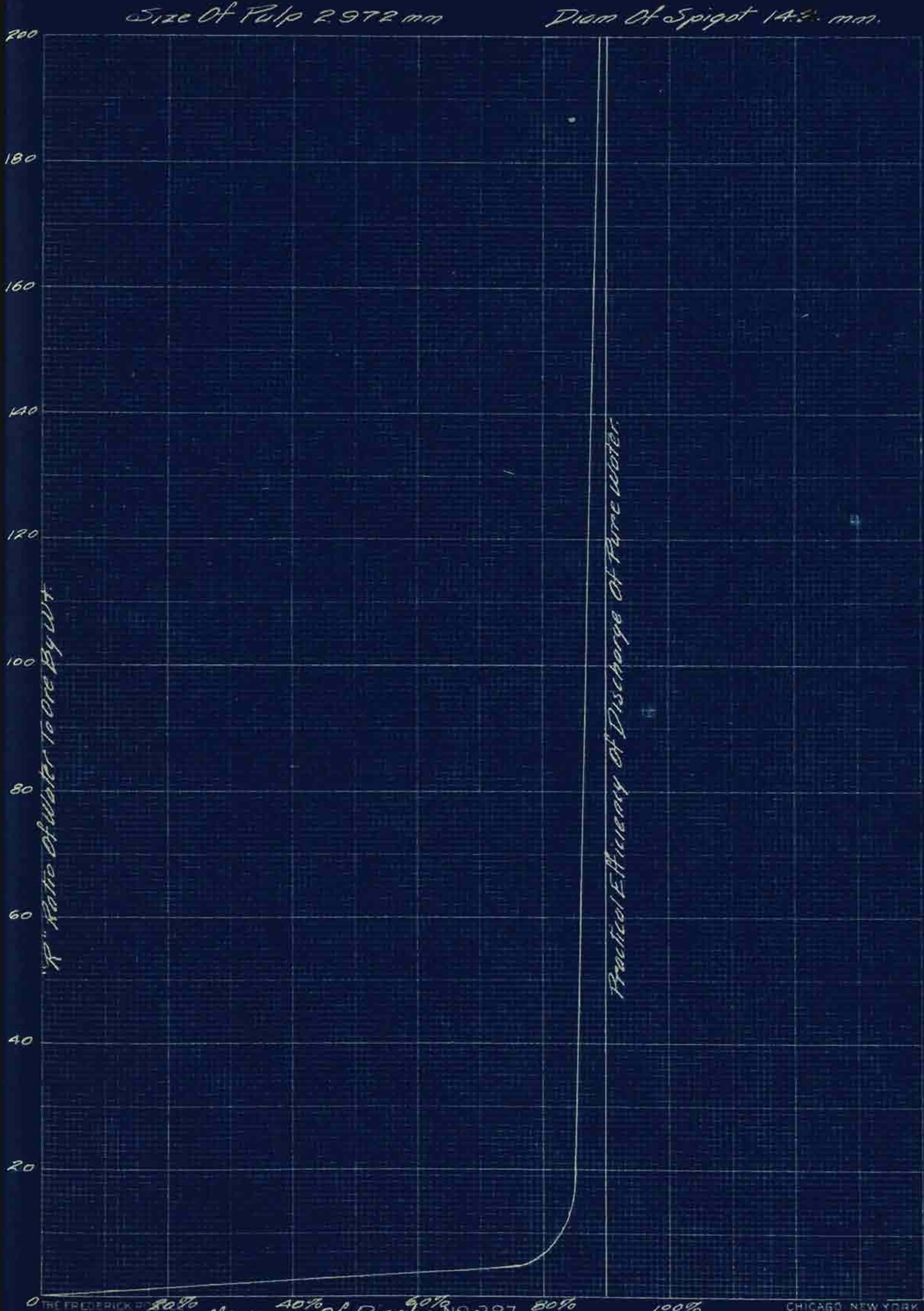
Size Of Pulp 4 mm. Diam Of Spigot 18.3 mm

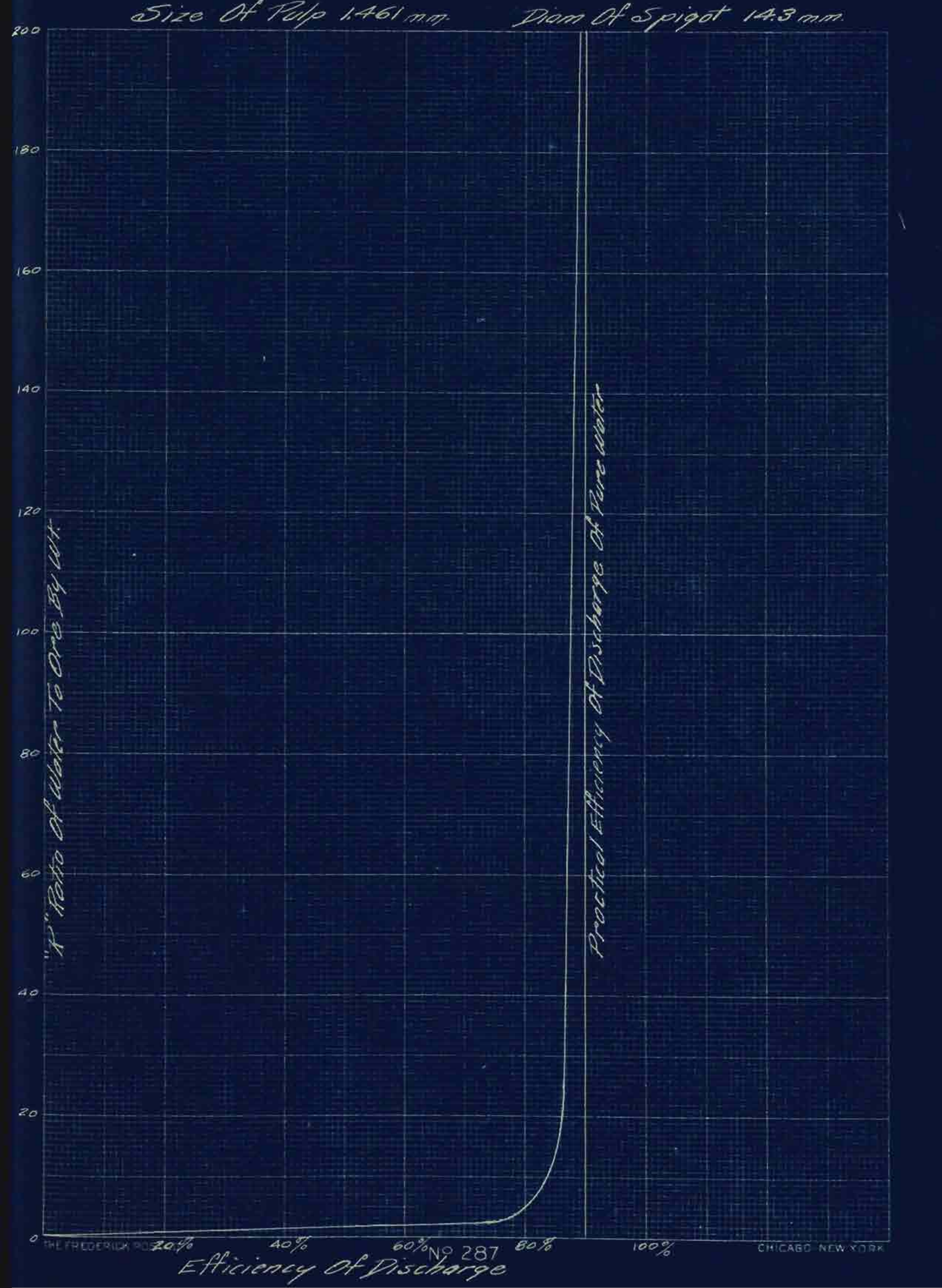




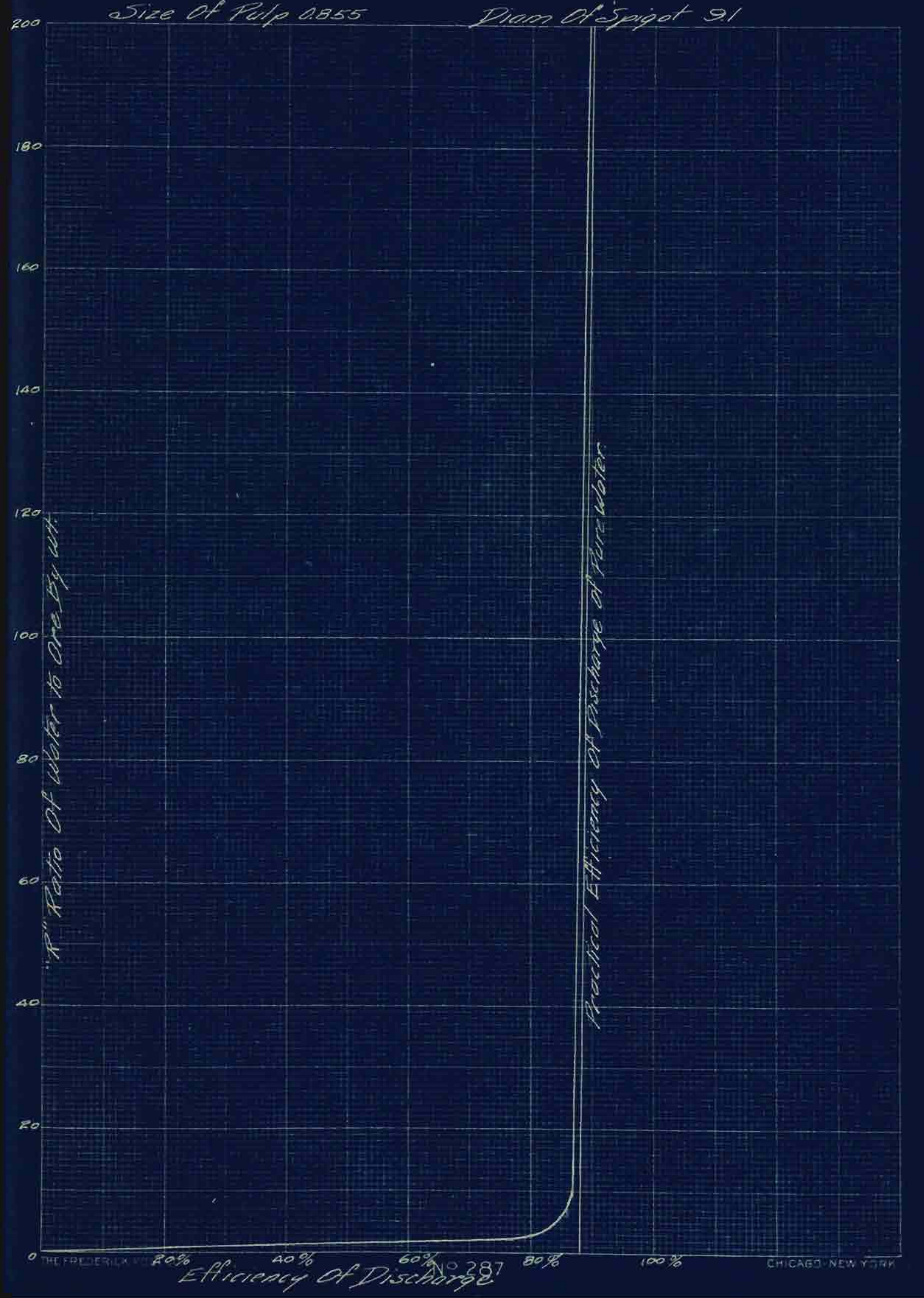
Size Of Pulp 2.972 mm.
Diam Of Spigot 18.3 mm.
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water To Ore By Wt.
Practical Efficiency Of Discharge of Pure Water
20%
40%
60%
80%
100%
Efficiency Of Discharge.
THE FREDERICK PO
No 287
CHICAGO NEW YORK



Size Of Pulp 2.972 mm
Diam Of Spigot 14.3 mm.
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water To Ore By Wt.
Practical Efficiency Of Discharge Of Pure Water.
20%
40%
60%
80%
100%
Efficiency Of Discharge
THE FREDERICK PO
No 287
CHICAGO NEW YORK


Size Of Pulp 1.461 mm.
Diam Of Spigot 14.3 mm.
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water To Ore By Wt.
Practical Efficiency Of Discharge Of Pure Water
20%
40%
60%
80%
100%
Efficiency Of Discharge
THE FREDERICK POST CO.
No 287
CHICAGO NEW YORK

Size Of Pulp 1.461
Diam Of Spigot 9.1
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water To Ore By Wt.
Practical Efficiency Of Discharge Of Pure Water
20%
40%
60%
80%
100%
No. 287
Efficiency Of Discharge
CHICAGO NEW YORK



Size Of Pulp 0.855
Diam Of Spigot 9.1
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water to Ore By Wt.
Practical Efficiency Of Discharge Of Pure Water
20%
40%
60%
80%
100%
Efficiency Of Discharge
THE FREDERICK POST CO.
No 287
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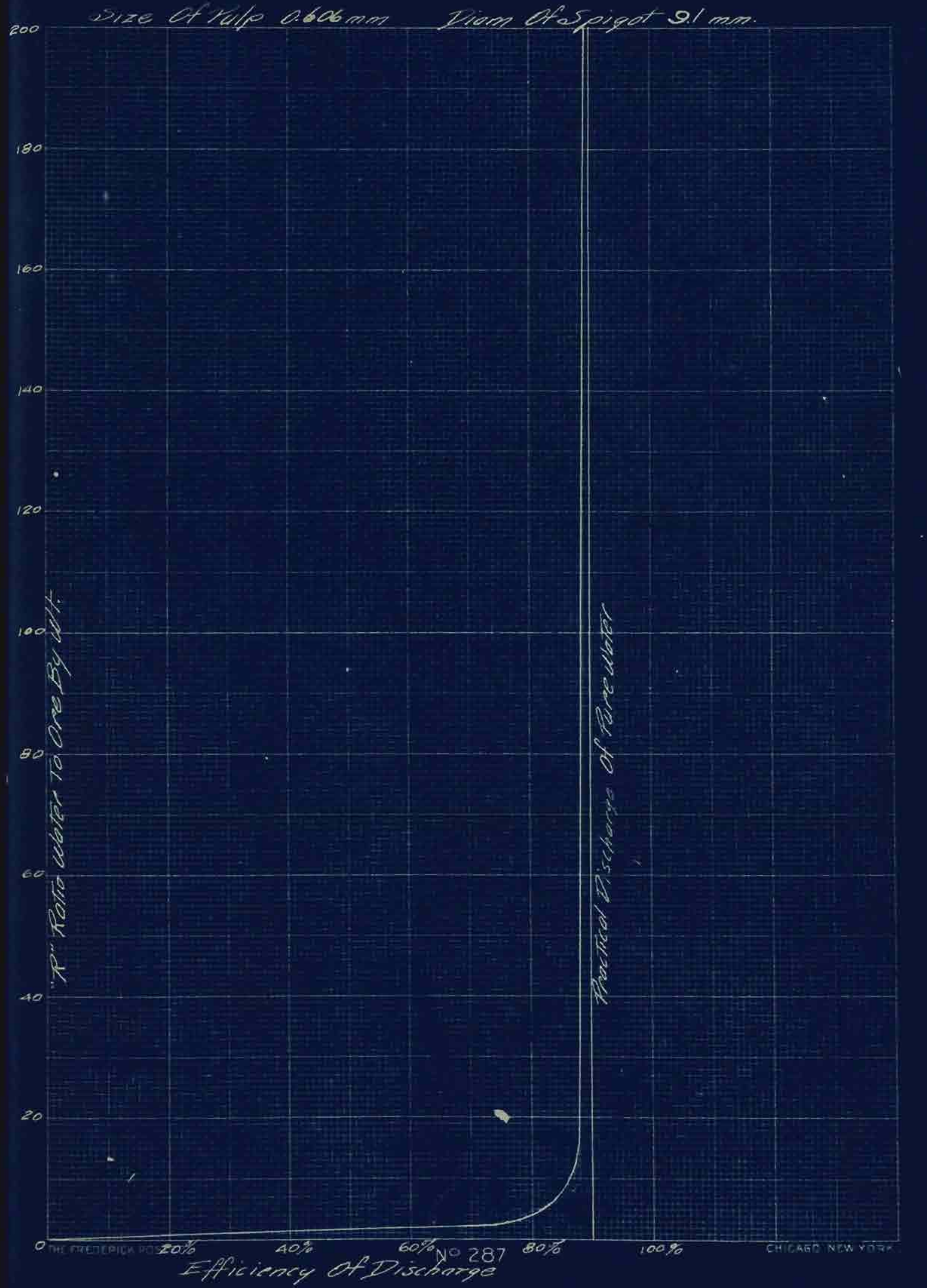

Size Of Pulp 0.606 mm Diam Of Spigot 9.1 mm.
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Water To Ore By Wt.
Practical Discharge Of Pure Water
20%
40%
60%
80%
100%
Efficiency Of Discharge
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No 287
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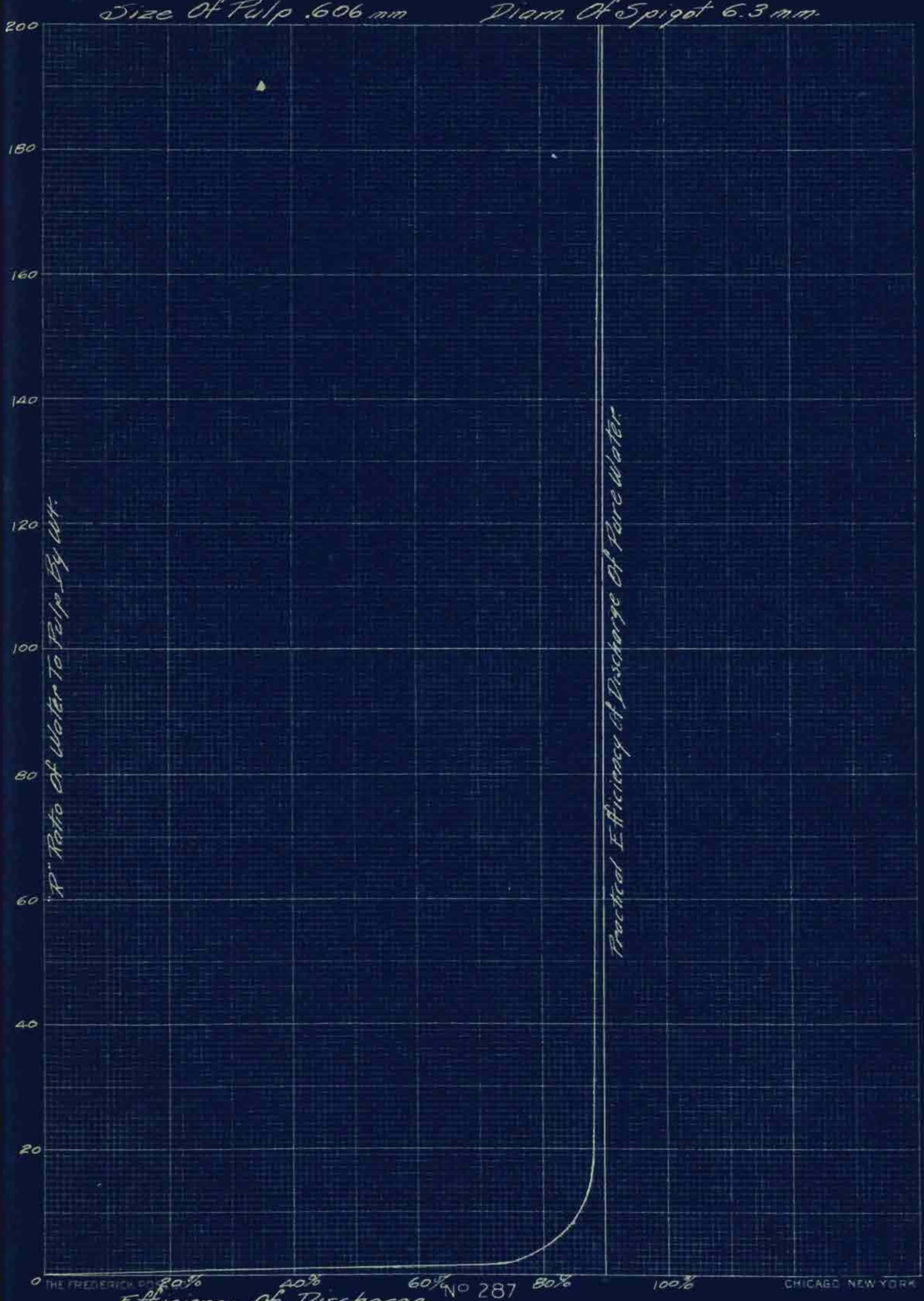
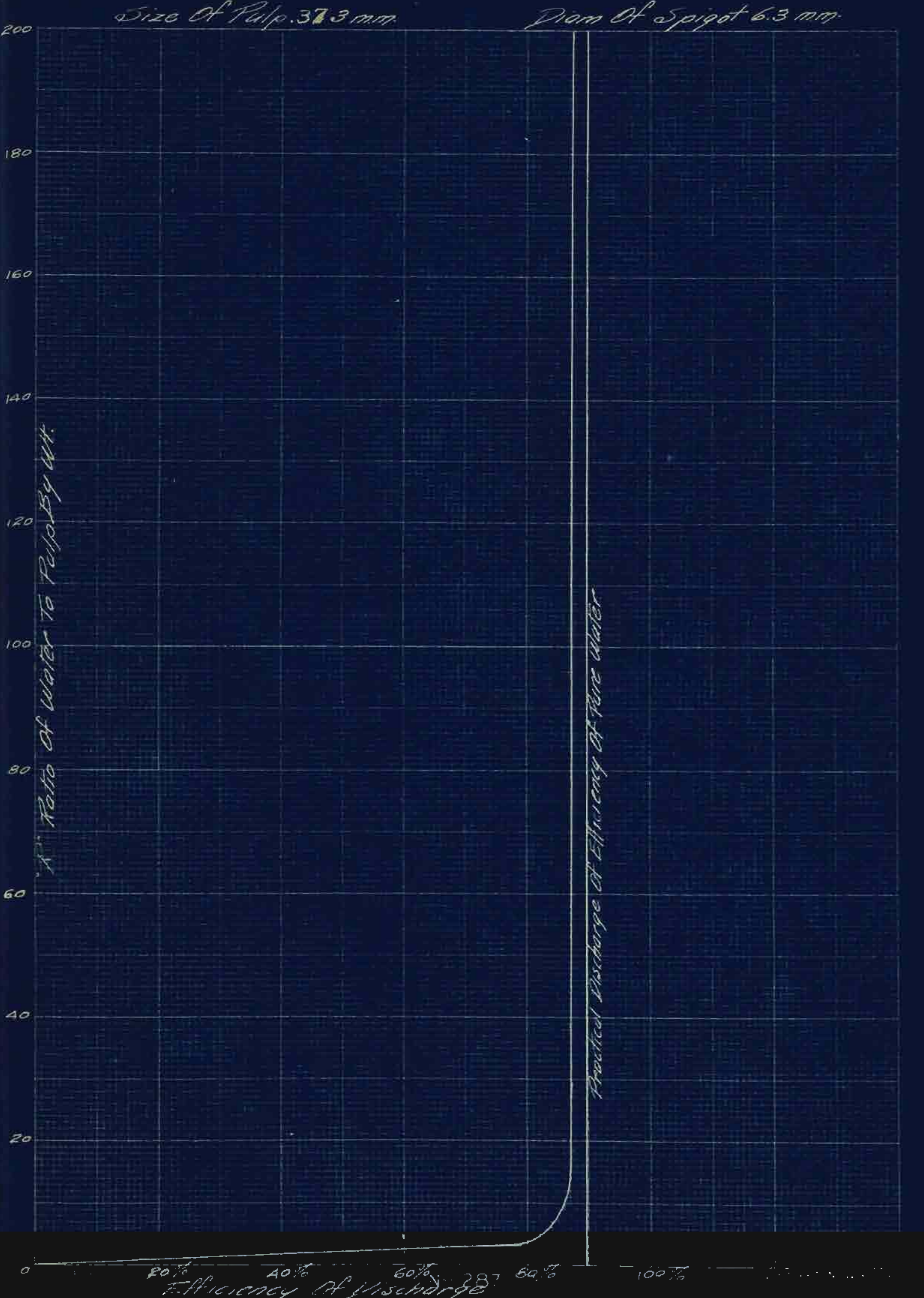


Size Of Pulp .606 mm
Diam. Of Spigot 6.3 mm.
200
180
160
140
120
100
80
60
40
20
0
"R" Ratio Of Water To Pulp By Wt.
Practical Efficiency Of Discharge Of Pure Water.
20%
40%
60%
80%
100%
Efficiency Of Discharge
No 287
CHICAGO NEW YORK


Size Of Pulp .373 mm.
Diam Of Spigot 6.3 mm.
"R" Ratio Of Water To Pulp By Wt.
Practical Discharge Of Efficiency Of Pure Water
200
180
160
140
120
100
80
60
40
20
0
20%
40%
60%
80%
100%
Efficiency Of Discharge
28